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MULTI-FUNCTION SLURRY DELIVERY SYSTEM

TECHNICAL FIELD

001 The present invention relates generally to semiconductor fabrication methods and systems. The present invention also generally relates to chemical mechanical polishing (CMP) devices and techniques thereof. The present invention additionally relates to slurry delivery methods and systems.

BACKGROUND OF THE INVENTION

002 Integrated circuits are typically formed on substrates, particularly silicon wafers, by the sequential deposition of conductive, semiconductive or insulative layers. After each layer is deposited, the layer is etched to create circuitry features. As a series of layers are sequentially deposited and etched, the outer or uppermost surface of the substrate, i.e., the exposed surface of the substrate, becomes successively more non-planar. This occurs because the distance between the outer surface and the underlying substrate is greatest in regions of the substrate where the least etching has occurred, and least in regions where the greatest etching has occurred. With a single patterned underlying layer, this non-planar surface comprises a series of peaks and valleys

wherein the distance between the highest peak and the lowest valley may be the order of 7000 to 10,000 Angstroms. With multiple patterned underlying layers, the height difference between the peaks and valleys becomes even more severe, and can reach several microns.

003 This non-planar outer surface presents a problem for the integrated circuit manufacturer. If the outer surface is non-planar, then photo lithographic techniques used to pattern photoresist layers might not be suitable, as a non-planar surface can prevent proper focusing of the photolithography apparatus. Therefore, there is a need to periodically planarize this substrate surface to provide a planar layer surface. Planarization, in effect, polishes away a non-planar, outer surface, whether conductive, semiconductive, or insulative, to form a relatively flat, smooth surface. Following planarization, additional layers may be deposited on the outer surface to form interconnect lines between features, or the outer surface may be etched to form vias to lower features.

004 Chemical mechanical polishing is one accepted method of planarization. This planarization method typically requires that the substrate be mounted on a carrier or polishing head, with the surface of the substrate to be polished exposed. The substrate is then placed against a rotating polishing pad. In addition, the carrier head may rotate to provide additional motion between the substrate and polishing surface. Further, a polishing slurry, including an abrasive and at least one chemically-reactive agent, may be spread on the polishing pad to provide an abrasive chemical solution at the interface between the pad and substrate.

005 Important factors in the chemical mechanical polishing process are: the finish (roughness) and flatness (lack of large scale topography) of the substrate surface, and the polishing rate. Inadequate flatness and finish can produce substrate defects. The polishing rate sets the time needed to polish a layer. Thus, it sets the maximum throughput of the polishing apparatus.

006 Each polishing pad provides a surface, which, in combination with the specific slurry mixture, can provide specific polishing characteristics. Thus, for any material being polished, the pad and slurry combination is theoretically capable of

providing a specified finish and flatness on the polished surface. The pad and slurry combination can provide this finish and flatness in a specified polishing time. Additional factors, such as the relative speed between the substrate and pad, and the force pressing the substrate against the pad, affect the polishing rate, finish and flatness.

007 For the development of chemical mechanical polishing technology in the 0.13 um range and beyond, a number of challenges must be overcome, particularly in light of slurry delivery systems. In order evaluate new types of slurries, it is necessary to control the flow rate of such slurries and the mixing ratios of newly mixed slurries. To date, an effective method and system for controlling slurry flow rate and mixing ratios has not been achieved. In addition, an effective slurry flow rate control and mixing ratio method and system is necessary to mass production applications. The present inventors have concluded, based on the foregoing, that a need exists for a new method and system for controlling slurry flow rate and mixing ratios thereof.

BRIEF SUMMARY OF THE INVENTION

008 The following summary of the invention is provided to facilitate an understanding of some of the innovative features unique to the present invention, and is not intended to be a full description. A full appreciation of the various aspects of the invention can be gained by taking the entire specification, claims, drawings, and abstract as a whole.

009 It is therefore one aspect of the present invention to provide an improved semiconductor fabrication method and system.

0010 It is therefore another aspect of the present invention to provide an improved method and system for delivering a slurry utilized in a chemical mechanical polishing operation.

0011 It is still another aspect of the present invention to provide in-line mixing for and accurate control of flow rates of slurries utilized in chemical mechanical polishing operations.

0012 It is yet another aspect of the present invention to provide pre-mixing functions, including accurately controlled rates thereof, for slurries utilized in chemical mechanical polishing operations.

0013 The above and other aspects of the present invention can thus be achieved as is now described. A method and system for delivering a mixed slurry for use in a chemical mechanical polishing operation is disclosed herein. According to the present invention described herein, a first slurry may be delivered for use in a chemical mechanical polishing operation. The first slurry may be mixed with a second slurry to provide a mixed slurry thereof. A flow rate and a mixing ratio associated with the mixed slurry can be controlled to provide an accurate control of the flow rate and adjustable mixing ratios for use in enhanced chemical mechanical polishing operations utilized in the fabrication of semiconductor devices.

0014 The first slurry and the second slurry may be mixed in-line utilizing an in-line mixing mechanism to provide a mixed slurry thereof. In an in-line mixing scenario, the mixing ratio may be adjusted by controlling the flow rate of the mixed slurry

and/or the first slurry and/or second slurry. Alternatively, the first and second slurries may be pre-mixed utilizing a pre-mixing mechanism to provide a mixed slurry there. In a pre-mixing scenario, the mixing ratio may be adjusted by measuring the weight of the first slurry and/or the second slurry. The pre-mixing mechanism may comprise a pre-mixing tank, such that the pre-mixing tank is associated with at least one load cell to control the mixing ratio.

0015 The flow rate of the mixed slurry delivered from the pre-mixing tank to a chemical mechanical polishing device can be controlled utilizing a slurry pump associated with the-pre-mixing tank. The mixed slurry can thereafter be delivered to the chemical mechanical polishing device and/or systems thereof. The pre-mixing mechanism and the in-line mixing mechanism may be integrated into a multi-function slurry delivery system and/or device. The first slurry can be delivered from a first supply tank linked to at least one circulation pump, wherein the circulation pump is operable in association with at least one slurry pump. The second slurry can be delivered from a second supply tank connected to at least one circulation pump, wherein the second supply tank is operable in

association with at least one slurry pump. The first and second supply tanks are operable in association with at least one valve.

BRIEF DESCRIPTION OF THE DRAWINGS

0016 The accompanying figures, in which like reference numerals refer to identical or functionally-similar elements throughout the separate views and which are incorporated in and form part of the specification, further illustrate the present invention and, together with the detailed description of the invention, serve to explain the principles of the present invention.

0017 FIG. 1 depicts a block diagram illustrating a multi-function slurry delivery system, in accordance with a preferred embodiment of the present invention; and

0018 FIG. 2 illustrates a high-level block diagram illustration a multi-function slurry delivery system, in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

0019 The particular values and configurations discussed in these non-limiting examples can be varied and are cited merely to illustrate embodiments of the present invention and are not intended to limit the scope of the invention.

0020 FIG. 1 depicts a block diagram illustrating a multi-function slurry delivery system 10, in accordance with a preferred embodiment of the present invention. System 10 generally includes a first supply tank 12 and a second supply tank 14. Supply tank 12 can contain a slurry A, while supply tank B can contain a slurry B. Supply tank 12 is connected to a circulation pump 16. Supply tank 14 is generally connected to a circulation pump 18. Circulation pump 16 is connected to supply tank 12 by lines 17 and 13 through which a slurry may flow.

0021 A slurry may thus enter supply tank 12 though line 12 and exit through line 17. A valve 32 is situated between circulation pump 16 and a delivery pump 20 on line 33. Line 33 is connected to line 13. A line 37 connects delivery pump 20 to an in-line mixing mechanism 30, which can be utilized to control the flow rate and mixing ratio of a slurry being mixed via in-line mixing mechanism

30. In-line mixing mechanism 30 in turn can deliver a slurry (e.g., a mixed slurry) to a chemical mechanical polishing device 38 or system thereof through line 29. In-line mixing mechanism is additionally connected to a delivery pump 22 by a line 23 through which a slurry may flow.

0022 Delivery pump 22 is connected to a line 41 which is connected to a valve 36, which in turn is connected to a line 15 that is connected to a line 19. Line 19 connects circulation pump 18 to supply tank 14 (i.e., second supply tank). Slurry can be delivered to supply tank 14 through line 19 and can exit supply tank 14 through a line 21, which in turn is connected to circulation pump 18. A line 46 is connected to line 19. Line 46 is connected to a valve 38, which in turn is connected to a line 48. Line 48 is connected to a pre-mixing mechanism 24, which can be configured as a pre-mixing tank.

0023 Pre-mixing mechanism 24 is associated with one or more load cells 40, 42, and 44. Pre-mixing mechanism 24 is additionally connected to a line 49 which can deliver slurry (i.e., pre-mixed slurry) to a delivery pump 26 which in turn can deliver the slurry via a line 47 to chemical polishing device 28. Delivery pump 26

can be utilized to control the flow rate of a slurry being mixed in pre-mixing mechanism 24. The mixing ratio of the slurry delivered via pre-mixing tank 24 can be adjusted by measuring the slurry's weight.

0024 One or more load cells 40, 42 and 44 can be utilized to control the mixing ratio of the slurry being mixed in pre-mixing mechanism 24. Slurry can enter pre-mixing mechanism 24 through line 48 or a line 43. Line 43 is connected to a valve 34 which in turn is connected to a line 35 that is connected to line 13. A slurry can thus be delivered directly to chemical mechanical polishing device 28 from first supply tank 12 or second supply tank 14.

0025 FIG. 2 illustrates a high-level block diagram illustration a multi-function slurry delivery system 50, in accordance with a preferred embodiment of the present invention. Note that system 50 of FIG. 2 is analogous to system 10 of FIG. 1. System 50 generally includes an in-line mixing mechanism 52 and a pre-mixing mechanism 54. In-line mixing mechanism 52, as indicated at block 56, permits a slurry mixing ratio to be adjusted by controlling the flow rate of the slurry. Pre-mixing system 54, as

indicated at block 58, permits a mixing ratio of the slurry to be adjusted by measuring the weight of the slurry. In-line mixing mechanism 52 of FIG. 2 is generally analogous to in-line mixing mechanism 30 of FIG. 1. Pre-mixing mechanism 54 of FIG. 2 is generally analogous to pre-mixing mechanism 24 of FIG. 1.

0026 Pre-mixing mechanism 52 can thus be implemented separately or together with pre-mixing tank 54 to form system 50. System 50 provides an innovative process capability with in-line and pre-mixing functions in one recipe. System 50 can supply slurry to a varying CMP tools and is compatible with a variety of CMP processes (e.g., W, STI, ILD, Cu, etc). System 52 can be easily applied to mass production scenarios and operations, and can solve the slurry contamination problem caused by the use of central supply systems. System 52 can also provide a local supply system for every CMP machine or device currently in use in industry.

0027 Based on the foregoing, it can thus be appreciated that FIG. 1 and FIG. 2 generally describe a method and system for delivering a mixed slurry for use in a chemical mechanical polishing operation is disclosed herein. According to the present invention described herein, a first slurry may be delivered for use

in a chemical mechanical polishing operation. The first slurry may be mixed with a second slurry to provide a mixed slurry thereof. A flow rate and a mixing ratio associated with the mixed slurry can be controlled to provide an accurate control of the flow rate and adjustable mixing ratios for use in enhanced chemical mechanical polishing operations utilized in the fabrication of semiconductor devices.

0028 The first slurry and the second slurry may be mixed in-line utilizing an in-line mixing mechanism (e.g., in-line mixing mechanism 42) to provide a mixed slurry thereof. In an in-line mixing scenario, the mixing ratio may be adjusted by controlling the flow rate of the mixed slurry and/or the first slurry and/or second slurry. Alternatively, the first and second slurries may be pre-mixed utilizing a pre-mixing mechanism (e.g., pre-mixing mechanism 24) to provide a mixed slurry there. In a pre-mixing scenario, the mixing ratio may be adjusted by measuring the weight of the first slurry and/or the second slurry. The pre-mixing mechanism may comprise a pre-mixing tank, such that the pre-mixing tank is associated with at least one load cell to control the mixing ratio. The pre-mixing tank may also be connected to at least one delivery pump via a slurry line (e.g., line 49). Such a

delivery pump (e.g., delivery pump 26) can permit a slurry to be pumped to a chemical mechanical polishing devices.

0029 The flow rate of the mixed slurry delivered from the pre-mixing tank to a chemical mechanical polishing device can be controlled utilizing a slurry pump associated with the-pre-mixing tank. The mixed slurry can thereafter be delivered to the chemical mechanical polishing device and/or systems thereof. The pre-mixing mechanism and the in-line mixing mechanism may be integrated into a multi-function slurry delivery system and/or device. The first slurry can be delivered from a first supply tank (e.g., supply tank 12) linked to at least one circulation pump, wherein the circulation pump is operable in association with at least one slurry pump. The second slurry can be delivered from a second supply tank (e.g., supply tank 14) connected to at least one circulation pump, wherein the second supply tank is operable in association with at least one slurry pump. The first and second supply tanks are operable in association with at least one valve.

0030 The embodiments and examples set forth herein are presented to best explain the present invention and its practical application and to thereby enable those skilled in the art to make

and utilize the invention. Those skilled in the art, however, will recognize that the foregoing description and examples have been presented for the purpose of illustration and example only. Other variations and modifications of the present invention will be apparent to those of skill in the art, and it is the intent of the appended claims that such variations and modifications be covered. The description as set forth is thus not intended to be exhaustive or to limit the scope of the invention. Many modifications and variations are possible in light of the above teaching without departing from scope of the following claims. It is contemplated that the use of the present invention can involve components having different characteristics. It is intended that the scope of the present invention be defined by the claims appended hereto, giving full cognizance to equivalents in all respects.